





ORIGINAL ARTICLE

The public economic burden of suboptimal type 2 diabetes control upon taxpayers in Sweden: Looking beyond health costs

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Abstract

Aim: To estimate the fiscal burden for taxpayers in Sweden associated with type 2 diabetes (T2D) attributed to diabetes-related complications in patients failing to meet HbA1c targets.

Material and Methods: We developed a public economic framework to assess how changes in diabetes-related complications influenced projected tax contributions and government disability payments for people with T2D. The analysis applied accepted disease-modelling practices to estimate different rates of diabetes-related complications based on an HbA1c of 6.9% (52 mmol/mol) and of 6.0% (42 mmol/mol). We adjusted the employment activity rates for those experiencing T2D-related events, applying age-specific earnings to estimate lifetime tax losses. Furthermore, the likelihood of receiving payments for health-related employment inactivity was estimated. Direct healthcare costs are excluded from this analysis.

Results: The estimated per person earnings loss for immediate and delayed HbA1c control was Swedish krona (SEK) 42 299 and SEK 44 157, respectively, over 10 years. The lost employment activity of people with T2D translates to lost tax revenues of SEK 23 265 and SEK 24 287 for immediate and delayed control, respectively. The estimated difference in disability payments was SEK 538. Combining the tax revenue loss and excess disability payments defines the broader fiscal costs, where we observe combined fiscal losses that favour immediate and sustained control by SEK 1560 over 10 years.

Conclusions: We show that conducting fiscal analysis of diabetes interventions offers an enriched perspective capturing a range of costs that fall on government in relation to lost tax revenue and disability payments. Tax-financed health systems may benefit from broadening the consideration of costs and benefits when evaluating new interventions and treatment practices.

KEYWORDS

diabetes complications, economic evaluation, glycaemic control, public economics, taxes, type 2 diabetes

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1 | INTRODUCTION

Type 2 diabetes (T2D) is often undertreated, resulting in poor patient outcomes that reduce quality of life and limit an individual's ability to work (including presenteeism, absenteeism, and premature exit from the workforce).¹ Long periods of uncontrolled hyperglycaemia before treatment is intensified are common for patients worldwide.² For example, Khunti et al. found that patients in the UK with uncontrolled blood glucose levels waited on average for more than 3 years to intensify treatment from one to two oral agents.³ Additionally, in Sweden, data indicate that a staggering 45% of individuals with T2D and 30% of recently diagnosed individuals had suboptimal glycaemic control in 2019.⁴

The direct and indirect (i.e. foregone labour market productivity) costs associated with this 'clinical inertia' are sizeable.^{5,6} For example, Ali and colleagues estimated that delaying therapy intensification for the 13 million US patients with an HbA1c of 9.0% (75 mmol/mol) by just 1 year was associated with a loss of 13 390 life-years and direct and indirect cost increases of US\$7.3 billion over 1 year,⁶ and Bain et al. estimated the direct and indirect costs in the UK over 10 years at £2.6 billion.⁵ In both cases, the indirect costs of foregone labour market productivity exceeded the direct medical costs.

However, the implications for society extend beyond direct medical costs and indirect costs of foregone labour market productivity, and governments are well aware of the importance of population health for maintaining economic growth, improving living standards, and maintaining a healthy tax base (including good employment prospects and high incomes).⁷⁻¹² Diabetes-related complications have been shown to reduce annual incomes¹³ and the impact has been observed across the full working age spectrum.¹⁴ These complications have also been linked to an increased need for disability pensions that can increase costs for governments (but are omitted from economic evaluation because transfer payments redistribute income and wealth without directly absorbing resources or creating output). For example, a previous assessment found that depression, musculoskeletal problems, and multiple co-morbid conditions all increased the likelihood of receiving disability pensions.¹⁵

Recognizing these broader consequences of diabetes on governmental finances, we sought to quantify the effects of T2D on fiscal outcomes for the Swedish government based on delays in achieving glycaemic treatment targets.¹⁶ Building on evidence showing the impact of diabetes and related complications on work activity, a fiscal analysis was conducted that describes how efforts to reduce clinical inertia in the treatment of T2D can influence future government tax revenues and transfer payments (e.g. disability allowances or economic inactivity) from the perspective of the Swedish Treasury. We focus on permanent work transitions such as retirement and disability and exclude the impact of absenteeism and presenteeism, which are short-term productivity measures that are mostly absorbed by employers.^{17,18} The fiscal outputs described in our analysis can be used to complement cost-effectiveness studies that show a broader range of costs to government in addition to the traditional healthcare costs related to poor glycaemic control.

2 | METHODOLOGY

The fiscal analysis model was designed to capture long-term government public economic consequences attributable to T2D-related complications based on delays in achieving glycaemic targets compared with immediately achieving glycaemic control.¹⁶ The model was constructed in Microsoft Excel and is presented schematically in Figure 1. Specifically, the model follows a closed cohort of individuals with T2D over time, calculating the magnitude of lost wages, lost tax revenues, and disability payments under current status quo conditions and under the assumption that clinical inertia can be eliminated. The analysis described here intentionally excludes direct medical costs as these have been the dominant focus of previous economic studies of diabetes, and are well documented in Sweden.¹⁹

2.1 | Model structure

The model distinguishes between the incidence of new events and prevalence, explicitly accounting for 120 macrovascular combinations and 100 microvascular combinations because an individual can experience more than one event. Each trace provides for all combinations of complications, and an assumption of independence was used to combine the microvascular and macrovascular traces. For each event, the age at the time of event is considered, and the likelihood of retiring or leaving the workforce. Acute events such as hypoglycaemia are not believed to have any residual fiscal consequences and are not considered in our fiscal projections.

Three types of outcomes are evaluated in the model. First, for individuals who continued working after experiencing T2D-related events, we applied established wage reductions, because of the changing employment conditions that occur following complications, resulting in less tax being paid.¹⁴ Second, diabetes complications can influence employment rates, which can directly influence government tax revenues.^{8,10,12} Lost tax revenues were estimated by deriving age-specific earnings and applying known tax wedge rates in Sweden. The difference between immediate glycaemic control and delays in achieving control was used to derive the lost tax revenue for the government. Third, the model accounts for the likelihood of an individual experiencing a diabetes complication who then becomes disabled, therefore requiring public benefits assistance.

The delays in achieving treatment targets do not have direct fiscal consequences because of higher blood glucose levels; however, these delays increase the likelihood of experiencing diabetes-related events that are known to influence work activity, retirement, and disability status.^{10,12} These differences in event rates were used to estimate the impact on employment, taxes paid, and disability payments received. The fiscal analysis was based on disease modelling performed using a validated and previously published model from Sweden, and which is briefly described below.²⁰

2.2 | Linking diabetes complications to fiscal outcomes

Prevalence data were sourced from simulation results using an established economic model of diabetes, the Swedish Institute for

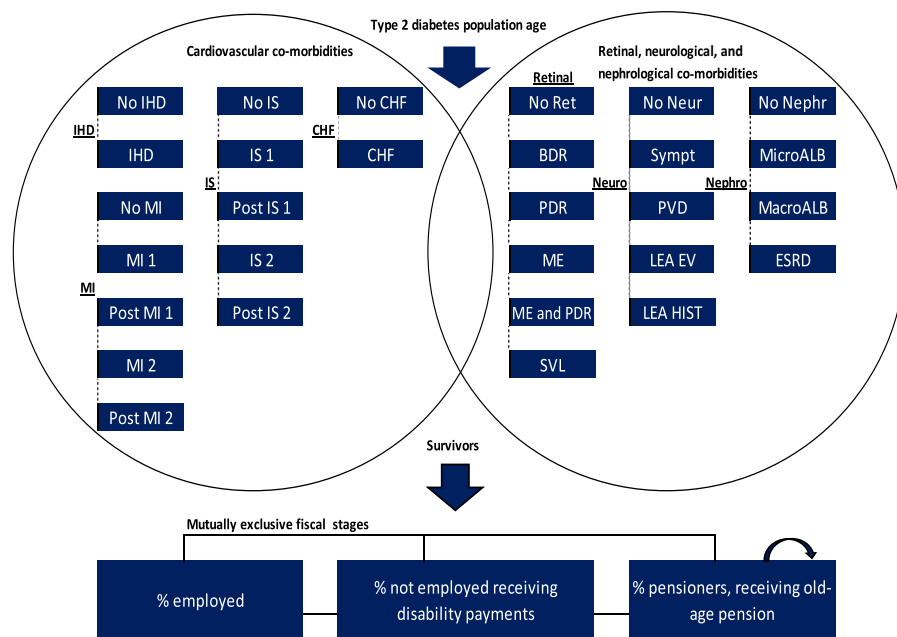


FIGURE 1 Fiscal model design. BDR, background diabetic retinopathy; CHF, coronary heart failure; ESRD, end stage renal disease; IHD, ischaemic heart disease; IS, ischaemic stroke; LEA EV, lower extremity amputation extracellular vesicles; LEA HIST, lower extremity amputation history; MacroALB, macroalbuminuria; ME, macular oedema; MI, myocardial infarction; MicroALB, microalbuminuria; No Nephro, no nephrological complication; No Neur, no neurological complication; No Ret, no retinopathy; PDR, proliferative diabetic retinopathy; PVD, peripheral vascular disease; SVL, severe visual loss; Sympt, symptomatic neurological complication

Health Economics Diabetes Cohort Model (IHE-DCM).²⁰ The IHE-DCM is described in more detail in Appendix S1, but briefly it is a long-term Markov cohort model that includes the development and progression sets of long-term microvascular and macrovascular complications and acute adverse events such as hypoglycaemic events. The model has been validated by simulating 167 outcomes for 12 long-term clinical studies and comparing model predictions with actual observed outcomes. The match was generally good, with an R^2 of 0.96 (Figure S1). Two of the clinical studies may be particularly relevant for this study based on tight glucose control, the United Kingdom Prospective Diabetes Study (UKPDS), and the Swedish National Diabetes Registry (NDR). Individual results for these studies are presented in Figures S2 and S3, with R^2 values of 0.93 and 0.75, respectively.

The Markov traces were linked to different fiscal states (described below). Every year in the model, patients with T2D transition between these health states. Individuals in the model could experience more than one co-morbidity over the time horizon, with varying fiscal impact. The different combinations of co-morbidities considered within the modelling are provided in the supporting information. It is worth noting that the disease modelling produces combinations of cardiovascular (CV) co-morbidities and combinations of retinal, neurological, and nephrological co-morbidities separately.

Patients with T2D may simultaneously experience multiple complications. Adjusting for double counting for patients experiencing multiple complications was performed to avoid the overestimation of fiscal effects (i.e. only one sick payment would be received regardless of how many disabilities a patient had). Co-morbidity-induced reductions in employment rates were adjusted for the prevalence of co-morbidity combinations after the adjustment for double counting and were subsequently monetized to

reflect the present value of income loss, tax loss, and disability costs (Figure 1).

From a fiscal perspective, prevalent cases with co-morbidities were assumed to experience reductions in their employment rates. The employment rate reduction applied in the model for a combination of co-morbidities was the additive effect of the co-morbidities. Risk ratios for not being employed following the occurrence of a diabetes-related co-morbidity are described in Figure S1. The risk ratios were informed by a structured, targeted literature review. For the combinations of co-morbidities, the additive effect of T2D co-morbidities was used.

The fiscal effect modelled was the combined reduction of employment attributed to T2D-related complications. This fiscal effect defined by the risk ratios in Figure 1 of the supplement was applied to the prevalence of co-morbidity combinations for a cohort of patients with T2D achieving immediate and sustained glycaemic control, considered as an HbA1c of 6.0% (42 mmol/mol),²¹ compared with delays in achieving control (a 1-, 3-, or 5-year delay). Reductions in employment rates for each cohort were monetized to reflect the present value of future income loss, tax loss, and excess disability transfer costs. The time period of the analysis was limited to 10 years; therefore, pension costs were not included.

The fiscal model assumed three mutually exclusive fiscal states, namely, employed, not employed, and receiving disability benefits. The fiscal transitions modelled were:

- Employment decreases by time and based on the severity and quantity of co-morbidities;
- The proportion of patients with T2D receiving disability payments increases based on the severity and quantity of co-morbidities, and proportionately to a decrease in employment rate;

- All patients with T2D surviving beyond the average retirement age were considered economically inactive, receiving only an old-age pension (not applicable in reported scenarios).

The equations for defining the changes in fiscal costs are provided in the supporting information.

3 | SCENARIOS ANALYSED

Several scenarios were analysed exploring the impact of delays in achieving glycaemic control over a 10-year time horizon. The analyses conducted were deterministic with respect to age and, thus, the cohort's average age was set at 54 years for a population aged 65 years or younger based on reported findings from the NDR in Sweden.^{4,16} For each scenario, we assumed a baseline HbA1c of 6.9% (52 mmol/mol) with a target of 6.0% (42 mmol/mol) based on guidelines for intensive glycaemic control for younger T2D cohorts.²² We explored the fiscal costs of delays in achieving an HbA1c of 6.0% (42 mmol/mol) for 1, 3, and 5 years for a range of

baseline ages (45, 50, 54, and 60 years) and time horizons (3, 10, and 40 years).

4 | MODEL INPUT VARIABLES

4.1 | Literature research

A targeted literature research was conducted to identify studies (1) supporting the conceptual fiscal analytical framework; and (2) reporting modelling inputs for the fiscal analysis. The overarching research objective was to identify and quantify fiscal effects and metrics that can be linked with the trace of the cohort originating from the IHE economic T2D evaluation model. As such, the focal point of the literature search was on fiscal metrics and not on clinical or humanistic metrics.

In summary, the majority of identified studies reported the impact of T2D on employment rates. Fewer studies reported the impact of diabetes on disability (Table 1). Data for the combined effect of diabetes and T2D co-morbidities are scarce in the literature. Geographically,

TABLE 1 Selection of key studies describing the impact of type 2 diabetes complications on fiscal metrics

Fiscal impact	Country	Measure	Relevance to complications	Quality	References
Impact of diabetes diagnosis	Multiple	Several studies, across different geographies, describe diabetes-attributable wage penalties and increased demand for transfer costs	Non-complication-specific (generic)	High	14,23-25
Impact on employment	United States	People with diabetes-related complications were 12% (5%-19%) less probable to be in the workforce. Confirmed by several other studies ^{14,23,24} identified by the literature research	Non-complication-specific (generic)	High	13
Reduction in wages/income	Canada	Individuals with diabetes complications have lower incomes at various age groups from 18 to 64 y confirmed by Kraut et al. study ¹⁴	Non-complication-specific (generic)	Older but highly cited, of good quality	14
Early retirement (study in those aged >57 y)	United States	Reduced odds ratio for not being retired: <ul style="list-style-type: none"> • Any complication 0.35 ($P < .001$) • Stroke 0.38 ($P < .001$) • Coronary 0.64 ($P = .002$) Confirmed by four more studies ^{9,25-27}	Data for, any complication; stroke; coronary	High	12
Receive disability pension	Sweden	Cumulative probability all-cause disability over 48 mo: CV disease, depression, >1 complication, no complication. Confirmed by evidence from various studies ^{9,14,28-30}	Data for CV disease, depression, >1 complication, no complication	High	15

Abbreviation: CV, cardiovascular.

TABLE 2 Data inputs used in the fiscal model

Input	Description	Source
Age-specific variables		
Age-specific employment rate and annual earnings	Income in Sweden 2018, personal communication with SCB	31
Proportion of individuals with disability	Social insurance in figures 2019: Page 40 graph with proportion of the population receiving disability allowance in December 2018. Data extracted from graph and averaged for men and women	31
Annual disability pension	Social insurance in figures 2019: average of monthly disability pension (pages 55-56) for males and females multiplied by 12	31
Average monthly pension	Average monthly pension x 12 from pensions	32
Non-age-specific variables		
Tax rates	Sum of tax wedge (2019), that is, 42.7% and percentage of income that goes to indirect tax (i.e. 12.3% based on OECD tax data [taxes of goods and services as % of GDP])	33,34
Cost inflation	Labour cost index, percentage change from corresponding month last year by economic indicator and month	35
Wage penalty postdiabetes diagnosis	A 5% reduction of earnings as obtained from Kraut et al. (2001)	14
Risk ratios (i.e. impact of co-morbidities on employment rates)		
Macular oedema (0.580)	The economic impact of diabetic macular oedema in Australia	36
Severe visual loss (0.068)	OR 14.8 not working with diabetes. The reciprocal OR was used to estimate employment rate	37
Peripheral vascular disease; lower extremity, history of amputation (0.488)	RTW 0.67; 0.33 do not return to work. RR = 0.33:0.67	38
Macroalbuminuria (0.248)	Socioeconomic status and type 2 diabetes complications among young adult patients in Japan. Model 2. Inverse of OR was used to calculate employment rate. The OR was used as a proxy for disability rate	29
Microalbuminuria (0.500)	We applied an intermediate work impairment rate between macroalbuminuria and 1.0. No specific input was found for microalbuminuria	29
ESRD (0.223)	Ghani et al. (2019) showed a 10.5% reduction in employment in transition from microalbuminuria and ESRD in Sweden. We applied the 10.5% reduction to the OR for macroalbuminuria to derive the OR for ESRD	39
IHD (0.640)	Impact of disease on employment for people nearing retirement age	12
MI, history of MI (0.710)	RTW data following MI	40
Subsequent MI (0.150)	Subsequent MI and employment, 82.4%/17.6%. Divide OR for RTW after first MI by 4.69	41
Stroke (0.380)	Finance memo. Impact of disease on employment for people nearing retirement age	12
Subsequent stroke (0.114)	Squared value of first stroke	Assumption
Heart failure (0.760)	Return to the workforce after first hospitalization for heart failure. A Danish nationwide cohort study	42

Abbreviations: ESRD, end stage renal disease; IHD, ischaemic heart disease; GDP, gross domestic product; MI, myocardial infarction; OR, odds ratio; OECD, Organization for economic co-operation and development; RR, risk ratio; RTW, return to work; SCB, Swedish community board.

most studies originated from the United States and the UK followed by studies reporting data from Scandinavian countries. Where multiple studies were available, it was not feasible to combine studies because of differences in cultural norms for work and legal statutes that dictate requirements for accessing public benefits. Table 1 presents the studies that were deemed representative of the fiscal impact associated with

T2D co-morbidities. These studies supported the conceptual analytical framework of the present study and were also used as data sources. Studies were selected based on geographical and conceptual relevance. Furthermore, the selected studies were mainly studies using large observational datasets to reflect broad population trends. More details of the literature search are presented in Appendix S1.

4.2 | Model input data

The fiscal results are primarily driven by (1) fiscal variables, which can be divided further into age- and non-age-specific variables; (2) risk ratios, which are used to adjust employment rates based on each comorbidity's impact on employment; and (3) the prevalence rate over time for the complications.

Table 2 summarizes the data inputs that were used in the fiscal model. All monetary inputs were expressed in 2020 Swedish krona (SEK) and discounted at an annual discount rate of 3%.

5 | RESULTS

The base case considering the likelihood of achieving glycaemic control within 3 years based on prior observations in Scandinavia⁴³ is described in Table 3. The estimated per person earnings loss for immediate and delayed control was SEK 42 299 and SEK 44 157, respectively. The lost employment activity of people with T2D translates to lost tax revenues for the Swedish government of SEK 23 265 and SEK 24 287 for immediate and delayed control, respectively. Combining the tax revenue loss and excess disability defines the broader fiscal costs, where we observe combined fiscal losses that favour immediate control by SEK 1560 over 10 years.

A series of scenario analyses was performed to illustrate the sensitivity of the fiscal model results to changes in baseline age, clinical inertia delay, and simulation time horizon (Table 4). The impact was greatest for the youngest cohort (aged 45 years), the longest (5-year) delay in glycaemic control, and the longest (40-year) simulation horizon. The fiscal consequences over the 3-year time horizon were minimal.

6 | DISCUSSION

Early and intensive glycaemic control to achieve an HbA1c of 6.0%–6.9% (42–52 mmol/mol)²² is recommended in Sweden for people recently diagnosed with T2D and/or of younger ages, which overlaps with working ages. The lower treatment goals (42–48 mmol/mol) are recommended for people with long expected survival (aged 50–55 years or younger at diagnosis), no manifest CV disease or other co-morbidity, and who are treated with pharmaceuticals without risk of hypoglycaemia. While these extremely tight treatment goals have been difficult to achieve in practice, with 44.2% of the T2D population failing to reach these targets,⁴ Sweden has been generally successful in managing blood glucose in much of the population.²¹ In the Swedish NDR, mean HbA1c was 6.9% (52 mmol/mol) in the working age population in 2019¹⁶ and only 11% of the overall T2D population in Sweden had an HbA1c that exceeded 8.5% (>69 mmol/mol) in 2016.²¹ Hellgren et al.¹⁶ estimated the clinical and economic impacts of bringing these patients to goals of 6.0% (42 mmol/mol) and 6.5% (48 mmol/mol) (i.e. eliminating clinical inertia) and found sizeable population cost offsets for the Swedish healthcare setting could be achieved because of the better resulting health.^{16,19} We leveraged

this work to address the related question of what fiscal benefits would be achievable by eliminating clinical inertia from the perspective of the Swedish Treasury. We found that working-age patients with poor blood glucose values to goal and reducing the rates of debilitating macrovascular and microvascular complications additionally reduces the fiscal burden of diabetes (i.e. disability payments and tax losses), and that the benefits increase with the length of the clinical inertia. Although the overall contribution of lost tax revenue and transfer cost savings are limited because this patient population is comparatively healthy and the simulated events are comparatively uncommon over a 10-year time horizon, the fiscal impact is sizeable when amplified across the working-age T2D population. Furthermore, the benefits of improved control need to be viewed in light of additional healthcare cost savings that can be achieved by reducing diabetes-related complications.¹⁹

The impact of T2D and related complications on fiscal outputs were conservatively underestimated, and a number of potentially important types of costs were omitted from the analysis. First, only permanent work transitions (i.e. discontinuation of work because of their health condition) were considered and absenteeism was excluded. Second, indirect costs related to foregone productivity (including presenteeism) are large—as much as 35% of the overall burden of diabetes⁴⁴—are not considered here because they do not pose direct fiscal costs (although they may generate fiscal costs indirectly through reduced firm profitability and corporate tax payments). Third, costs associated with long-term family caregiving of patients with diabetes (e.g. requiring reduced work hours or discontinuation entirely) are not considered. Previous studies have highlighted the likelihood of a spouse retiring in response to an event such as a stroke or myocardial infarction and is probable to be applicable to the population described here.⁴⁵ Finally, economic losses can be extended to government and society attributed to deadweight losses that arise from people with T2D who are unable to work and have an increasing reliance on public benefits. Every individual unable to work and thus reliant on public benefits requires the remaining workers to pay higher taxes to support increasing public benefits and healthcare costs for those individuals. This necessitates raising taxes to pay for benefits programmes, which causes supply and demand to be out of equilibrium, potentially leading to market inefficiencies. Consequently, the remaining workers have less disposable income and will buy fewer goods, which impacts upon firms and reduces tax revenues for the government from reduced value added tax. We highlight this link, although it is not quantified in our analysis, because it illustrates the interdependency among members of society through public economics and how all members of society are influenced by increasing rates of diabetes.

Estimation of the fiscal health impact is comparatively rare in the health economics field, but the methodology of recent examples and guidelines^{46,47} is helping the approach to catch on as a complement to traditional health economic analysis. The analysis described here helps to fulfil the call for broader economic frameworks upon which to evaluate treatment practices and new technologies and create value-driven healthcare systems.⁴⁸ In most European countries, health systems are pay-as-you-go tax-financed systems, therefore they rely upon people of working age paying taxes to fund the health service.

TABLE 3 The per patient fiscal impact of delayed glycaemic control of 3 years in the population aged ≤ 65 years, baseline HbA1c 6.9% (52 mmol/mol), HbA1c 6.0% target (42 mmol/mol), with 10-year time horizon (SEK) discounted

Economic variables	Immediate control (SEK)	3-y	
		delayed control (SEK)	Difference (SEK)
Earnings loss (societal perspective)	42 299	44 157	-1858
Government perspective			
Tax revenue loss (A)	23 265	24 287	-1022
Excess disability payments (B)	12 317	12 855	-538
Incremental fiscal effects (SEK) (A + B)			-1560

Abbreviation: SEK, Swedish krona.

Time horizon, y	Delay in achieving target, y	Age 45 y	Age 50 y	Age 54 y	Age 60 y
		(SEK)	(SEK)	(SEK)	(SEK)
3	1	39	64	92	150
	3	88	144	206	334
10	1	226	361	511	291
	3	702	1110	1560 ^a	787
	5	1147	1800	2518	1037
40	1	17 342	8560	589	291
	3	19 101	10 083	1809	787
	5	20 950	11 617	2954	1037

Abbreviation: SEK, Swedish krona.

^aBase case.

TABLE 4 Scenario analysis for baseline HbA1c 6.9% (52 mmol/mol) and achieving HbA1c target 6.0% (42 mmol/mol) based on variations in age, delays in achieving target, and time horizon

The fiscal approach helps to understand how investments in healthcare can directly influence the amount of tax revenue available with which to fund the system. An added advantage of fiscal analysis is how death is handled in the analysis. Rather than censoring events, death has fiscal losses for the government in the form of lost taxes, as well as fiscal gains from reduced expenditure on public benefit programmes, both of which are accounted for in our analysis. To this point, the fiscal framework applied here can partially help to understand sustainability and intergenerational fairness in relation to healthcare spending.⁴⁶

To our knowledge, there are no other estimates of the fiscal health implications of reducing clinical inertia, either in Sweden or anywhere else. Previous studies have reported the impact of T2D on the ability of people to remain active in the workforce,⁴⁹ and how employment activity can also be exacerbated by those experiencing diabetes-related complications further reducing employment activity and the likelihood of becoming disabled and requiring public benefits.¹² In this analysis, however, we build on this to consider the consequences of diabetes-related complications that extend beyond direct costs by taking into consideration lost tax revenues and transfer costs paid by the government.

This study has a number of strengths. The fiscal analysis model described here utilizes Markov traces from an established diabetes modeling framework that has been validated using Swedish data and published in Sweden.^{20,50} The results from the scenario analysis, in which age was varied, returned comparable results with the base case. Finally, the considered population was based on data from the Swedish NDR, which captures the majority of all patients diagnosed with T2D in Sweden.

The current study also has a number of limitations. First, the estimated magnitude of fiscal effects may be underestimated substantially and should be interpreted as a lower bound. Second, the use of mean (representative patients) ignores the proportionally larger health (and economic benefits) that are associated with improving the health of individuals with poor health than those with worse health (i.e. the benefits of marginal improvements in control are smaller for a patient near to goal than for a patient far from goal), which may further reinforce the underestimation. The expected fiscal benefits may be larger in certain patient subgroups. Thirdly, this study was limited to reducing clinical inertia in blood glucose management. Expanding intervention to include improvements in other biomarkers such as blood pressure, cholesterol, and body weight would presumably further decrease the number of complications that are simulated, and thus would provide an even greater fiscal impact in total. Finally, none of the identified studies in the literature review reported relative measures of impact for all diabetes complications. As such, the estimates used in our analysis are made from a compilation of studies identified in the published literature. This may confound the results when estimates are not drawn from an identical population.

Cost-effectiveness analysis plays an important role in being applied to treatment guidelines in diabetes for improving healthcare efficiency.⁵¹ A cost-effectiveness analysis has shown that intensive glycaemic control, as recommended in treatment guidelines for some patients, is economically justifiable.⁵² The evidence provided here offers additional support for intensive and immediate and sustained

control of T2D, further supported by the fiscal results described here that underscore the importance of intensive therapy and broader economic gains for governments. The results estimated here apply strictly to the Swedish setting, not only for population health but to the particulars of the labour market and social insurance system as well. There may be some transferability of these findings to at least similar country settings (e.g. similar population health and public benefits); however, and as observed in our literature review (see Appendix S1), the relationship between diabetes complications and work activity is well established in the literature across a diverse range of countries.

7 | CONCLUSION

Improving clinical control of T2D in the working-aged cohort in Sweden is expected to reduce fiscal tax losses for the government attributed to morbidity and premature mortality associated with T2D and its associated complications. Moreover, achieving immediate and sustained T2D glycaemic control may lead to reduced demand for disability transfer payments, and thus lower disability costs for the government. The results of the fiscal analytical framework presented and implemented here show that effective T2D glycaemic management may result in benefits for the public economy. While fiscal gains are not typically included in economic evaluations, they may be a useful complement when considering the sustainability of tax-financed public healthcare services.

CONFLICT OF INTEREST

NK and MPC received funding from Novo Nordisk in relation to their academic contributions to this work. Both NK and MPC hold no financial interests in the sponsoring organization. MW and AN are employees of the Swedish Institute for Health Economics, which provides consulting services for governmental bodies, academic institutions, and commercial life science enterprises (including Novo Nordisk A/S). ÅE and JBK are employees of Novo Nordisk. The authors had full editorial control regarding manuscript content. The sponsoring organization was given a chance to review this paper, although the final content was determined by the authors.

AUTHOR CONTRIBUTIONS

Concept development: N.K., M.P.C., J.B.K. Model development: N.K., M.P.C., A.E., J.B.K., M.W., A.N. Input identification: N.K., M.P.C., A.E., J.B.K., M.W., A.N. Interpretation of results: N.K., M.P.C., A.E., J.B.K., M.W., A.N. Writing of manuscript: N.K., M.P.C., A.E., J.B.K., M.W., A.N. Final review of manuscript: N.K., M.P.C., A.E., J.B.K., M.W., A.N.

PEER REVIEW

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DATA AVAILABILITY STATEMENT

The research modeling described here was developed using publicly available data. No proprietary data were used in this analysis. No individual patient data were used in the analysis.

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